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THE GEOMETRIC DESIGN OF NEW JAKARTA-CIKAMPEK HIGHWAY ACCESS USING AUTOCAD CIVIL 3D®: A CASE OF WEST KARAWANG INDUSTRIAL AREA

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ABSTRACT

Along with the development of the industrial sector in Indonesia, Karawang has excellent opportunities and potential to develop in this field, where Karawang currently has congestion problems from and towards industrial estates in a certain period. The geometric planning of the access road to the Jakarta-Cikampek Toll Road aims to provide references and preliminary designs to unravel the congestion problem. Systematic calculations and integrated visual depictions of AutoCAD Civil 3D® software assist the geometric design process of such roads. The research method used is quantitative. The necessary data sources are obtained from observation methods, literature studies, and primary data. Planning begins with determining the design criteria of the purpose and the function of such roads. Then the design criteria are used as a reference to determine variables in horizontal and vertical paragraphs. From the results of horizontal paragraph planning, one arc of FS (Full Circle) and 2 SCS (Spiral-Circle-Spiral) were obtained. Then the results of the vertical paragraph design got two concave arches.

INTRODUCTION

Traffic highways are the central transportation infrastructure for connecting one place to another. From the national main road to the village road is a vital infrastructure connecting a place. In recent economic activities today, the development of the industrial economy is so rapid that it occurs globally, in which transportation access is one of the essential facilities supporting industrial and economic progress in an area. The development of transportation facilities is the first step in building a region's industrial and financial activities paying attention to various aspects of investment calculations and future economic increases (Rahman, Radzi, & Doh, 2020).

China recently built a *highway* connecting Inner Mongolia with Northeastern China that will target access to China's economic activities associated from the northern part of China to the southern part of China. In terms of accelerating economic strengthening and the distribution of goods and services, the extension of roads and the construction of new roads as (Shi, et al., 2022) *highways* are carried out by the Chinese state. Geographical and topographical barriers and congestion are factors for constructing mega projects in China (Shang, Ye, Wu, & Shang, 2022).

As the largest country in Southeast Asia, Indonesia, during the Joko Widodo administration, designed several infrastructure developments, one of which was a national road construction project that connected many regions to support the acceleration of economic growth in Indonesia. One example is the Jakarta-Bandung High-Speed Train mega project, Trans Papua, Patimban Port, and several significant global corporate investors' factories in several regions. The impact of this development has increased employment, and the rate of movement of goods and services has increased (CNBC Indonesia, 2019).

Karawang Regency is one of Indonesia's cities with the most significant industrial area. However, along with the development of the industrial economy, Karawang Regency has several transportation-related problems. The capacity of the Jakarta-Cikampek toll road access to several industrial estates in Karawang Regency often experiences severe congestion in the morning and evening when waves of workers leave and leave work. Toll access in this city only has two accesses: the East Karawang Toll Gate and the West Karawang Toll Gate. Meanwhile, the West Karawang Toll Gate area has four industrial estates: the KIIC industrial, the KNIC industrial, the Artha Hills Industrial Estate, and the Trans Hexa Industrial Estate. The Regent of Karawang was aware of the problem. During his reign, he planned to immediately propose the construction of a new access to the Jakarta-Cikampek toll road from West Karawang (Karawang Post, 2022).

In this paper, the author discusses the initial design for adding new toll road access in the West Karawang area using Autodesk *AutoCAD Civil 3D*®. In addition, the purpose of writing this journal is to provide initial references to road and transportation developers (in this case, the government) to overcome transportation problems in the Karawang industrial area, which is primarily located in the West Karawang area. Finally, it is done as a solutive step to untangle the congestion in the area.

LITERATURE STUDIES

Road Geometric Design

Road Geometric Design is a physical road design that produces cross-sectional output and road dimensions, vertical and horizontal paragraphs. In addition, road facilities must be met to achieve the criteria for a *safe* road. Therefore, safety is the main requirement and the main guideline for planning geometric roads. These things will then be processed into physical infrastructure that meets the specified criteria and design planning (Raghu, Gupte, & Juremalani, 2018); (Suwardo. & Haryanto, 2019).

Road Geometric Design expects design results, including physical roads. They are accurate site selections with the condition that the design best suits a needs and the type of road following the provisions of its traffic function. Road users, too, include fulfilling requirements and achieving efficiency, comfort, and safety. It also takes into account the economic value of the decent.

Geometric Design should provide a decent efficiency value with an eye on development costs and targeted economic value in the future. With attention to this, the geometric design of roads is the optimal geometric design of roads. Design that is not optimal will not produce road

functions that are of economic value and sustainable economic development (Raghu, Gupte, & Juremalani, 2018); (Abadiyah & Amalia, 2020)

The geometric design of the road has the primary purpose. Therefore, the main objectives of road geometry planning are to produce a safe and comfortable physical road, that is, a design considering: visibility, sufficient maneuverable space, and sufficient surface friction coefficient; economically valuable and efficient, and easy to implement; providing a uniform physical infrastructure concerning such types of road terrain.

Autodesk AutoCAD Civil 3D®

Currently, the development of designing infrastructure in the world is snowballing along with technological advances and the development of the global industry. However, an infrastructure design has complexities and complex problems, which are the main factors in the effectiveness and efficiency of the planning process. This problem has now been reduced by technological advances, where infrastructure planning is currently widely designed using the help of *computers* (Gaikawad & Ghodmare, 2020).

*AutoCAD Civil 3D®*is one of the infrastructure design application programs in the 3D form issued by Autodesk developers. In the program, many features facilitate infrastructure planning, especially in the geometric planning of transportation roads. For example, horizontal alignment, vertical alignment, and contour analysis are some of the geometric planning variables of the road that can be facilitated by *AutoCAD Civil 3D®*(Mandal, Pawade, & Sandel, 2019).

The concept of *dynamic modeling* has been used by this software, which features an integrated design process, where changes when designing will automatically *update* the entire integrated design process. With this feature, the geometric design of the road will be thoroughly integrated and create the effect of decent design work. Furthermore, according to journal data, after using the software, the calculation of the structure's analysis, evaluation, design, and review becomes more accessible and faster on average, about 30% - 50% of the time taken (Kusnadi, Gaus, & Rauf, 2022).

A comparison of the *AutoCAD Civil 3D®*program in the geometric design of roads using the manual method has a value far from the range of effectiveness and efficiency values given. Considering the current progress of Indonesia's national infrastructure, of course, this can be a reference for all academicians, practitioners, and researchers throughout the country to take advantage of technological developments (Chakole & Wadhai, 2022) *in engineering activities.*

National Roads

Based on their designation, transportation roads are divided into two types: Public Roads and Special Roads. Public roads are transportation roads intended for general purposes, such as national highways, district roads, to inter-village roads. On the contrary, a particular road is a transportation road intended as a road with a particular function and a specific user subject only—for example, particular roads, namely residential roads, roads in industry, and so on. Roads are divided by road status. Roads are divided into five types, one of which is national roads. National

roads are public roads organized by the national government consisting of primary arterial roads, primary collector roads connecting provincial capitals, toll roads, and national strategic roads (Directorate General of Wildlife Development, 2021).

National roads have considerable importance as one of the road network systems based on the function of roads. The national road is a road that connects many public interests ranging from the distribution of goods and services on a national scale which, if slightly hampered, will result in significant losses. Therefore, the development of national transportation roads needs to pay attention to the spatial structure of the territory that contains the city system and transportation network patterns (Junoasmono, Christian Umboh, Caroline Sutandi, & Arberto Gultom, 2020).

National transportation roads have an essential role in supporting economic, social, cultural, and environmental movements developed through regional development approaches to achieve balance and equitable distribution of national development. In the case of transportation barriers on national roads, deepening actions on the issue must be carried out to prevent obstacles to economic movement and distribution of goods and services on a national scale. In this case, a common approach in the federal road planning process is analyzing all related factors according to the existing problems (Phanias Girsang, 2018).

METHOD

The systematic scientific research process must begin with identifying the right problem. In research, procedural research is essential in analyzing or researching a topic. The research methodology describes the stages and processes of research that are objective to provide information related to research reviews. In this study, quantitative methods were used as the method to be used. Quantitative methods are research methods whose data sources are taken through samples of a mathematical nature (Rifai, Hadiwardoyo, Correia, & Pereira, 2016).

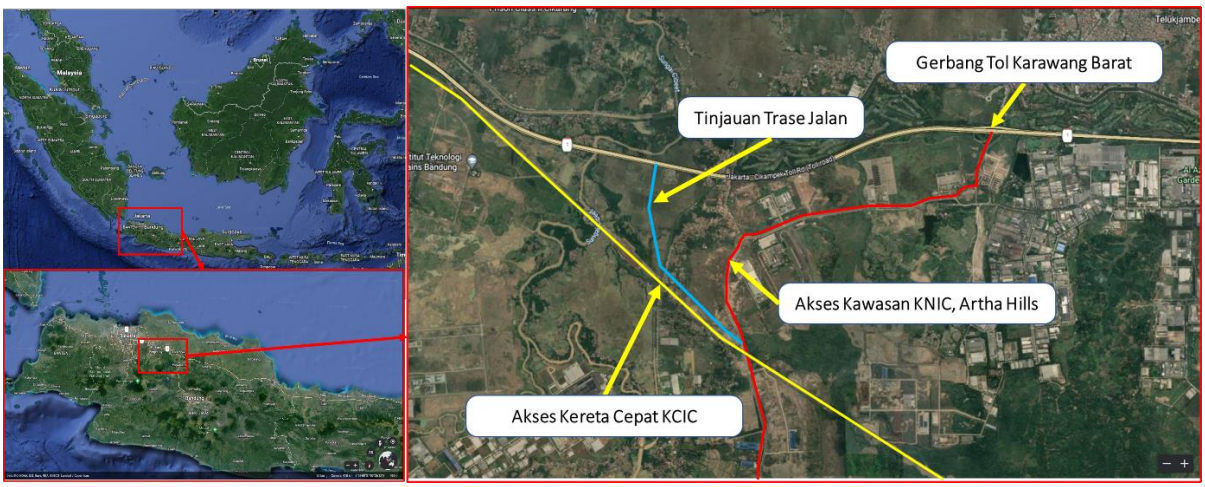


Figure 1. Location of research

The geometric design of the review road will use standard guidelines that will become the standard in determining the analysis of the data results obtained. The guidelines will be used: *Road Geometric Design Guidelines* in 2021 issued by the Ministry of PUPR, Directorate General of

Wildlife Development; Government Regulation no. 34 of 2006 on Roads; and Law no. 38 of 2004 on Roads.

The review location is in Karawang Regency, Trans Hexa Area Road. In addition, arterial roads KNIC industrial estate and Artha Hills will be reviewed in this paper. From the road, the study of the design of a new toll road access to the Jakarta-Cikampek toll road will be designed with an estimated road length of ±2 km to the Jakarta Cikampek KM32 toll road.

The data collection method in a study becomes very important, as it becomes information on how the data to input the research process is carried out. Data is one of the leading forces in compiling scientific research and modeling. Data retrieval on the review topic is taken from different types of methods. These data will be analyzed and processed in the review road design. Some data retrieval methods are as follows: observation methods; literary studies; and primary data (Rifai, Hadiwardoyo, Correia, Pereira, & Cortez, 2015).

RESULT AND DISCUSSION

Design Criteria

Based on observational data and a literature review of the review site, the main design criteria for the road design can be determined in Table 1

Table1. Design Criteria

No	Variable of Design	Value of Main Design Variable	
1	Connection purpose	Road of Trans Heksa Industrial Area and Artha Hills Industrial Area to the highway of Jakarta Cikampek KM32 as highway road access.	
2	Road Attribute	Type of Road	: General Road
		Road Network	: Secondary Network
		Status	: National Highway
		Purpose	: Road Artery Network
		Class	: I
		SPPJ	: JBH
3	Range of design speed		60 - 100 km/h

Horizontal Alinements

A minimum radius calculation (R_{min}) in horizontal paragraph planning requires several variables predetermined on the design criteria, as in Equation (I). From the design criteria, it can be taken that the design speed (v_D) is 100 km / h; then the maximum superelevation slope (e_{max}) of 8%; then the transverse friction coefficient (f_{max}) taken from tables 5-18 in the 2021 PDGJ book was obtained by 0.12. The calculation step is as follows:

$$R_{min} = \frac{{V_D}^2}{127\ (f_{max}+e_{max})} \quad \text{..... Equation (I)}$$

$$R_{min} = \frac{100^2}{127\ (0{,}12 + 0{,}08)} = 395\ m$$

From obtaining the minimum radius (R min), it can be determined that the plan (Rc) radius is 450 m. After that, the calculation of the minimum switching lane length (Ls_{min}) according to Equation (II) below is carried out by taking a travel time (T) of 3 seconds, then obtained as follows:

$$Ls_{min} = \frac{V_D}{3{,}6}\ T \quad \text{..... Equation (II)}$$

$$Ls_{min} = \frac{100}{3{,}6}\ 3 = 83{,}33\ m$$

Based on the results of the above calculations, it can be determined that the length of the intermediate arch is 90 m. Then, the design continues to determine the point of intersection, which can be seen in Figure 2 below. It shows the planning of the *effectiveness of the intersection* on the horizontal paragraphing.



Figure 2. Plan Horizontal and PI Point paragraph of the plan

From the planning results, the horizontal linemen of the road trace have two types of arches, namely Full Circle and *Spiral-Circle-Spiral*. There is 1 Full Circle and 2 Spiral-Circle-Spiral. In addition, there is one intersection at the end of the road traffic to connect this toll road access to the Jakarta-Cikampek KM32 Toll Road.

Vertical Alinements

The vertical paragraph planning at the review site was made ramps based on the classification of road terrain in the PDGJ book, Director General of Highways in 2021 in table 4-2, which is <10%. In Figure 3 below, you can see the existing condition of the contours traversed

by the road lanes, which are already classified as flat on the road lanes after STA +0.650. While at STA +0.000 to STA +0.600, there is hilly road terrain.

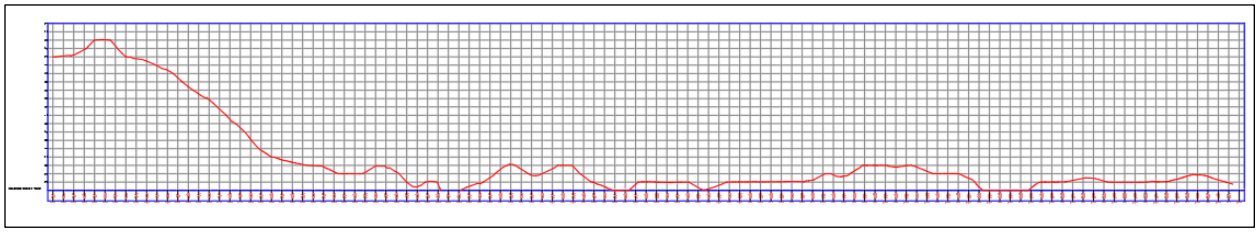


Figure 3. Contour Existing Vertical Alignment Trace Road Review

In the design of vertical paragraphs, STA +0.000 to STA +0.600 is made flat and follows a slope adjusted to the elevation of the existing national road Trans Hexa Area. As a result, to realize it, considerable *cutting* work is needed. On the other hand, STA +0.650 onwards has a reasonably gentle contour elevation with a maximum slump reached at 0.39% to adjust the elevation of the current level of the Jakarta-Cikampek KM32 Toll Road.

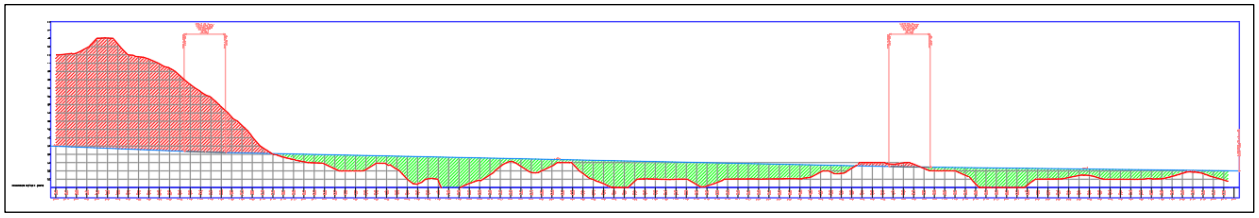


Figure 4. Road Trace Vertical Alignment Planning

Designing a Cross-Section of the Road

When planning for the road's cross-section, toll road lanes are made with four lanes, with each lane having two lanes with a road width of 7 m each lane with a *barrier* as a separator between the two lanes. Then the shoulder of the road of each lane is planned to be 2.4 m wide. Then the drainage planning for the initial projection is done with the *soil ditch* type. Finally, the planning of the cross-section of the road is obtained according to Figure 5 below.

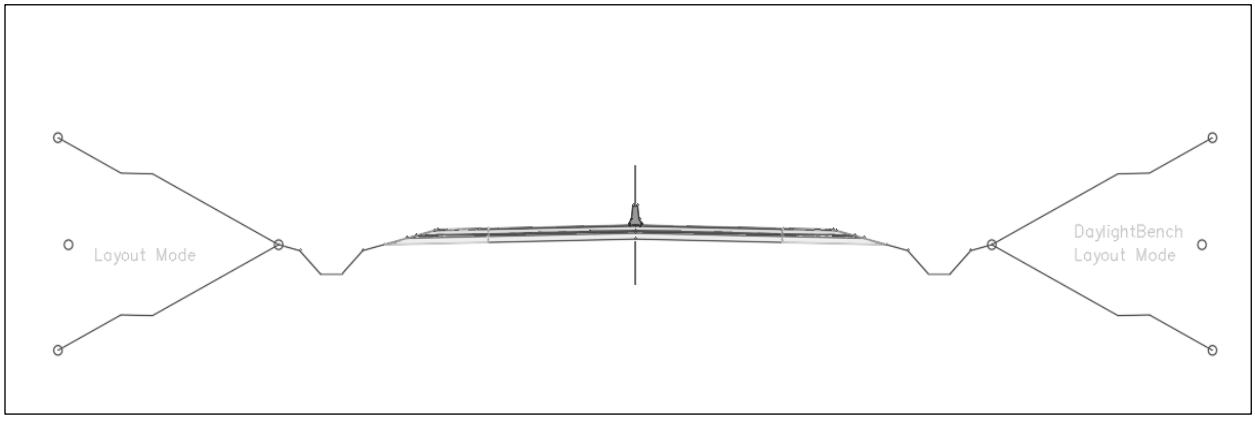


Figure 5. The Road Cross-Section Planning

Cross Section Extending the Road



Figure 6. Cross Section Extending the Road

From the results of planning horizontal alignment and vertical linemen, as well as planning corridors and cross sections of roads; as a result, the cross-section of the road lengthwise was obtained by *plotting* horizontal paragraphs integrated with vertical alignment assisted by *AutoCAD Civil 3D*®. The picture above shows that the red area is the cutting work area. In contrast, the green area is the stockpile area.

CONCLUSION

The results of data processing and planning of access to the new Jakarta-Cikampek KM32 toll road that connects the national road Trans Heksa Road to the Jakarta-Cikampek Toll Road with the help of *AutoCAD Civil 3D*® software can be drawn several conclusions. Horizontal paragraph planning has one full circle arch and two spiral-circle-spiral arches. In addition, the results of vertical paragraph planning have two concave arches. The Geometric Planning was successfully designed with the total road length being 1.65 km from the direction of the Trans Heksa Area Road to the Jakarta-Cikampek KM32 Toll Road.

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